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Assembly Reliability Modeling Technology Based on Meta-action

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Abstract

For the purpose of assembly quality control of CNC machine tools, this paper conducts the structure decomposition based on PFMA (Pedigree-Functions-Movement-Action ） for CNC Machine Tool, and proposed the concept of "functional spectrum ”. Take the movement function of CNC machine tools as a starting point, CNC machine tools were decomposed from the functional spectrum into the element action of the parts. In this process, we construct links to represent reliability quality relationships of element action assembly units, and then definite a link attribute called contribution degree, which measures the contribution of characteristics compared to links, for reliability analysis require of assembly process, and build a link network and link matrix model, finally, we use the link matrix model to the element action assembly units through the PFMA decomposition process from CNC rotary table to element action. The reliability was calculated to verify the applicability of the link model in the aspect of reliability quality characteristics structured modeling of element action assembly units.

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Keywords: quality control; meta action; assembly reliability; quality characteristic; linkage network; linkage matrix

1. Introduction

The assembly is to combine each kind of spare part together to realize the product function. Machinery assembly is the final stage of product manufacture process and the final linkage to form the product quality, which plays a very important role in product quality[1,2]. Product assembly quality means to what extent the intrinsic property of assembled mechanical products will satisfy the customer’s requirements, including the quality features of precision, precision retentivity, reliability and maintainability etc[3,4]. The reliability is an important index of the product quality, deciding the product usability. To enhance the product reliability, besides carrying on the fail-safe analysis and the design in the product design process, another important way is to carry out safeguard measure of the reliability in the assembling process, and to carry on the reliability prediction according to the safeguard measure to build the foundation for the anticipatory control of assembly quality.

Many scholars have conducted the researches on product assembly quality and reliable technology from different angles, and proposed the pertinent quality safeguard measurements and the craft control method to enhance the assembly qualified rate. Mr.SuQ.[5]has proposed the craft complexity analysis method, suitable for the mechanical and electrical products, which established the duplicator product’s dual statistical model of artificial assembly flaw and achieved good forecast effect. In view of the assembly shop reliability SuzukiT[6-9].proposed“Assembly Reliability Evaluation Method”, which conducted the quantitative investigation through the design factors and the workshop factors to the assembly failure rate, and improved the

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corresponding influence factors from the design to enhance the reliability level of assembly on the scene. Mr. J[10-16] adopted the gyre relevance analysis method of the gyre system theory to analyze the multi-geometry essential factor of product assembly system characteristic and determine the main influential geometry essential factor of assembly product quality characteristic.

The above mentioned methods about the mechanical and electrical products assembly quality research mostly concentrates on the technique and tried to promote assembly quality from the craft angle, which has provided the valuable theory and method for quality prevention and control in product assembly process. The assembly process control is one of product reliable keys that can guarantee the product quality. Each kind of breakdown in numerical control machines often occurred to the spare part. To enhance the reliability and prevent the breakdown, the simplified modeling and analysis process must be carried on to guarantee the reliability of component Meta action, and guarantee the reliability of functional unit and whole machine.

Therefore, this research started with the movement function decomposition of numerical control machine and carried on P-A structural decomposition to the numerical control machine. We decompose function spectrum to the level of component movement, and define movement level of the smallest decomposition granularity which can't be decomposed as the meta-action level to constitute the meta-action assembly unit. We take the meta-action assembly unit as the fundamental unit of the analysis, in view of structure linkage model in the meta-action assembly unit, and carry on the computation of its assembly reliability. A new method will be proposed in this paper from reliable modeling and analysis aspect in the assembly process.

2. Structural decomposition

The numerical control machine is a multi-disciplinary complicated system including mechanics, electricity, fluid, control, light etc.which possesses multi-functions and complex structure. The scientific research indicated that the complex system needs to be decomposed into basic units. By analyzing the elemental units, we can achieve the purpose of "from complex to simplification" and "from simplification to complex". Therefore, this paper firstly establishes the "Pedigree-Functions-Movement-Action"(PFMA) structural decomposition model, decomposes the numerical control machine to an meta-action, then at the level of meta-action carries on the reliable modeling of the meta-action assembly unit.

2.1. Pedigree and function spectrum

The numerical control machine in its service's life cycle will meet different components. The processing of different components will cause different loads, and the processing of different component shape will need different working components. It will result in that each spare part of the machine has the different breakdown probability in the process. This spectrum system used in this paper is to study the different contents. The system structure called as Pedigree can describe the complete work information of numerical control machine which is composed by component spectrum, operating mode spectrum, loading spectrum, function spectrum and malfunction spectrum according to the different work information in its service life cycle.

Numerical control machine will adopt different functions to process different components in its service process, and the combination of different functions can be called as function spectrum.For example, in the process of drilling, boring, tapping and reaming, the X, Y and Z axle of numerical control machine will realize feeding movement function, and the cooling and lubrication system must realize the auxiliary function of cooling and the lubrication. The research is conducted in this paper on movement function of function spectrum.

The establishment of spectrum system is the premise of research on numerical control machine's design, processing, assembly and application, which not only helps to enhance the precision, precision life and the reliability demand, but also shift the quality control from static state to dynamic state so as to enhance the accuracy of quality characteristic control in assembly process.contact with the profile from below along all the profile and taking the upper boundary of the disks.

2.2 Function, movement and action

There are some coupling relations among the function, movement and action. The numerical control machine can realize movement function of its function spectrum, mainly depending on relative motion of its various components. Movement function of numerical control machine is realized by the movements of various functional units, but functional unit's movement is realized by elementary action of its functional unit's components. As long as the reliability of component elementary action can be guaranteed, functional unit movement and product movement function can be guaranteed. Therefore, the key point to the reliability of complete machine product may be focused on the reliability of spare components which can be guaranteed through the assembly process.

2.3 Meta-actions and assembly unit of meta-action

This paper calls the minimum action of machine movement as meta-action. The meta-action acts as the smallest movement unit of system function whose reliability exerts important influence to system's normal operation. An meta-action can generally be divided into three types: 1) rotation: the rotation is the most common meta-action in machine processing process, such as electrical machinery rotation, lead screw rotation, gear-driven rotation, main axle rotation etc.2) movement: a movement meta-action mostly leads to feeding, the guide screw nut movement, the movement of cylinder and plunger etc.; 3) others: in the machine movement there are other meta-actions, such as push button, pull switch and turn handle etc. to change machine function. The structure composition of meta-action must be guaranteed with its correct assembly method. This paper calls the smallest assembly unit of meta-action in core components as the meta-action assembly unit.The meta-action structure of the gear-driven rotation as shown in Figure 1 is a typical meta-action assembly unit.

2.4 "PFMA" structural decomposition

The structural decomposition purpose of numerical control machine is to decompose the numerical control machine to the meta-action level and carry on the reliability analysis and computation in the level of meta-action assembly unit.

We can conduct the Pedigree-Function-Movment-A-structural decomposition of the numerical control machine as shown in Figure 2: First we may establish spectrum system of numerical control machine, and decompose the function to the level of spare part elementary action; Function spectrum of numerical control machine can be taken as the first level; Then the decomposition to part movement is the second level; Finally various components movement can be decomposed to spare part's elementary action which various movements will need, and we call it as bottom level or meta-action level.

The premise of reliability-driven assembly process is to decompose the movement function of complete machine to obtain meta-action of a spare part, and carry on the fail-safe analysis of the meta-action assembly unit again on the basis of decomposition.

In order to satisfy the product's certain function, the machine needs to realize the corresponding function movement, which is composed by a series of actions, just like some machining center's integrated function realized by a series of actions of some functional unit's sub-function. In order to guarantee the normal operation of numerical control rotary table and its indexing function, then such movements of the numerical control rotary table as indexing, returning to zero etc. must be normal. What's more, the indexing movement of numerical control rotary table is also composed by the movements of gyrator's relaxing, rotating and orientation etc. The movement level may be divided into the first-level movement, the second-level movement perhaps the third-level movement etc.The first-level movement is mainly referring to realizing the most direct action of product function movement; the second-level and the third-level movements are mainly referring to the detailed movements of some components (the smallest unit) as meta-action. For example, gyrator's rotation of some machining center's numerical control rotary table is the first-level movement, the rotation of worm and wheel is the second-level movement, and finally the last-level movement will be defined as a meta-action. Between the function and movement and between the movement and action there are some coupling relations. In order to carry on the effective analysis to the assembly quality, we need to consider carefully the coupling relations in the function decomposition process, and conduct corresponding research of product function through qualitative and quantitative analysis of a meta-action assembly process.

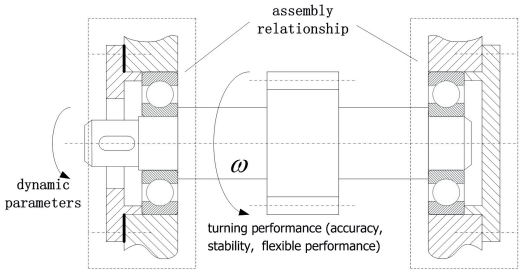


Fig. 1. The construction of Gear running meta action

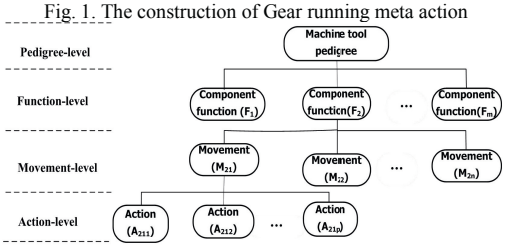


Fig. 2. " PFMA" modeling frame of Machine tools

3. Linkage model of meta-action assembly unit

In order to carry on the qualitative and quantitative reliability analysis of the structurally decomposed meta-action assembly unit, the concept of linkage is introduced and treated as the basic seal unit of meta-action assembly quality in this paper. And then the assembly quality modeling theory is proposed based on the linkage of meta-action unit.

3.1 Meta-action assembly unit linkage

Linkages: The basic seal unit of various components quality relations in meta-action assembly unit, can be expressed as, $y = f(x_1, x_2, \cdots x_n)$,where y is quality characteristic of meta-action assembly unit target

(output); $x_1, x_2, \ldots x_n$ is various component quality characteristic (input quality characteristic) of assembly unit; Function $f()$ is relation criterion between assembly meta-action unit target quality and various component quality characteristics of assembly unit.

The quality characteristic of various components among meta-action assembly unit will be expressed with the circle, relation criterion between assembly body target quality and quality characteristic of assembly component can be indicated with the rectangular frame. The connection between them can be indicated with the arrow to obtain the linkage presentation in figure or diagram. A reliability linkage for meta-action assembly unit of worm rotation in the numerical control rotary table is shown in Figure 3.

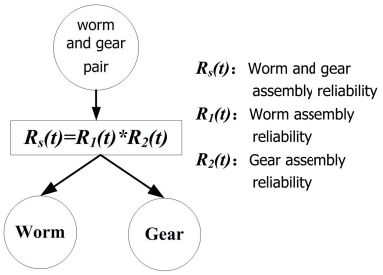


Fig. 3. Worm gear rotating meta action assembly unit Linkage graphical representations

Reliable worm and gear core components in meta-action assembly unit can guarantee the reliability of meta-action assembly unit. Worm rotation meta-action assembly unit is a cascade system, according to cascade system's reliability model, and then this meta-action assembly unit's reliability is the reliability product of such core components as worm and wheel etc. The reliability of domestic numerical control machine is not good, and its primary cause is the bad reliability of function component, which in the assembly process has great influence to the processing quality of complete machine and the components. The reliability of meta-action unit assembly process is the key factor to guarantee the reliability of the components and complete machine.

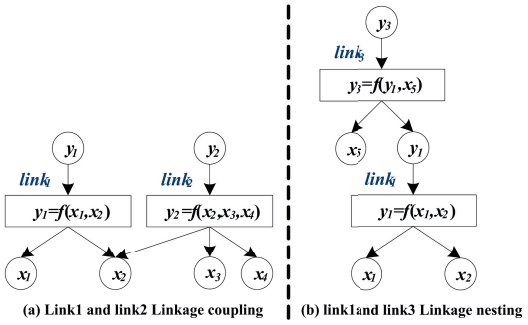
The 5M1E six factors in assembly process have great influence to the product quality and working procedure control, and can change the assembly target quality to cause quality loss. In order to satisfy the need of coupling effect analysis in the assembly process, because of such influencing factors as temperature, humidity, artificial operation difference etc. affecting the target assembly quality, the paper gives the following definition:

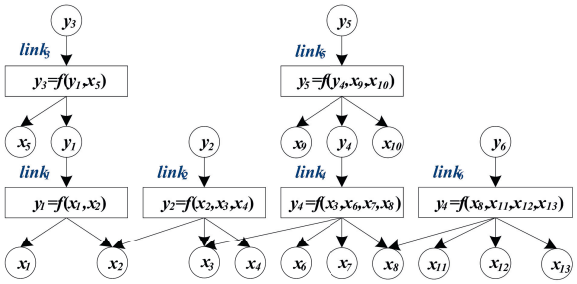
Contribution degree of characteristic to linkage: in the light of meta-action assembly unit, in its assembly process the various components of meta-action assembly unit will play different roles in the assembly target quality characteristic. Here, the definition of contribution degree is used to express the influence degree of each assembly body linkage reliability to the linkage reliability, and can be recorded as "Contri". The contribution degree characteristic can take value between [0,1] and may be obtained through quota partial differential computation and normalization processing. Lacking of information the expert can grade qualitatively the contribution degree. The contribution degree of target characteristic and the linkage is 1. The contribution degree of characteristic and linkage is the key point to measure quality control from the each assembly body to meta-action assembly unit or from the meta-action assembly unit to the component assembly process. The paper mainly focuses on the essential quality control point of the reliability in assembly process.

3.2 Assembly linkage network

The linkage expresses relation seal of meta-action assembly unit quality characteristic, but there are many assembly units in numerical control machine from component assembly to general assembly, and there are the same incidence relations between each linkage. According to various components' assembly relation of numerical control machine, the linkage of incidence relation can be divided into two kinds: Linkage coupling and linkage nesting. If $link_1 : y_1 = f(x_1, x_2)$; $link_2 : y_2 = f(x_2, x_3, x_4)$; $link_3 : y_3 = f(x_1, x_5)$;the n $link_1$ and $link_2$ is coupling for linkages, $link_1$ and $link_3$ nested for linkages, as shown in figure 4 (a) and (b).

The linkage through the coupling and nesting may form the complex connection network of assembly quality characteristic, namely Network based on linkage(NBL), as shown in Figure 4 (c).





(c) Network based on linkage(NBL)

Fig. 4. Network based on Linkage(NBL)

3.3 Assembly linkage matrix

The linkage network is based on the linkage of the meta-action assembly quality characteristic incidence relation, in the following meta-action assembly quality process needs to transform into structural linkage matrix to carry on the quantitative analysis of the meta-action assembly quality for the memory and the computation. Matrix based on linkage(MBL) mainly contains such three kinds of essential factors as the linkage, quality characteristic, and the quality characteristic contribution degree to linkage. It can adopt the structural method to define and describe the component quality characteristic and the incidence relations in the product assembly process, as shown in Figure 5.

	Comp A					*Comp B*			*Comp C*						*Comp D*			
	y_1	y_3	x_1	x_2	x_5	y_2	x_3	x_4	y_4	y_5	x_6	x_7	x_8	x_9	x_{10}	y_6	x_{11}	x_{12}	x_{13}
$y_1=f(x_1,x_2)$	1		0.2	0.9															
$y_2=f(x_2,x_3,x_4)$				0.2		1		0.4	0.6										
$y_3=f(y_1,x_5)$	0.2	1			0.2														
$y_4=f(x_3,x_6,x_7,x_8)$								0.3	1		0.5	0.2	0.6						
$y_5=f(y_4,x_9,x_{10})$									0.2	1				0.3	0.5				
$y_6=f(x_8,x_{11},x_{12},x_{13})$													0.8			1	0.4	0.6	0.3

Fig. 5. Assembly quality model:Matrix based on linkage(MBL)

The linkage matrix structurally adopts two levels of compound matrix constructions. Among them, the row element is the linkage; The first-level column element is the assembly component or the module, and the second-level column element describes quality characteristic of the component or module, and {0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0} marks contribution degree of quality characteristic of the component or module in the linkage with various components, which is the relation intensity of the linkage matrix unit value and the corresponding components. Contribution degree of target quality characteristic to the linkage is 1.0, and the quality characteristic which may not participate in the linkage can be set void.

The assembly linkage matrix is the basic model of essential quality characteristic control in the process reliability etc. Whether to accurately recognize incidence relations of various products quality characteristic may directly affect the efficiency of the quality characteristic control in the assembly process. In order to effectively control the essential quality characteristic reliability of product assembly process, the paper adopts the linkage matrix to carry on reliability computation in the assembly process.

3.4 Meta-action assembly unit reliability evaluate model

We can carry on P-A decomposition of the numerical control machine to the meta-action level, and movement level function realization of meta-action assembly unit can guarantee normal function of various functional units in numerical control machine realizes. But the assembly mission success ratio of meta-action assembly unit's may be measured by its reliability. The most obvious difference between machine and electronic product is that the machine not only has no redundancy design, but also no replaceable working pattern. Therefore the machine in the function is a huge cascade system, and each meta-action in the decomposition process is a serial system. Therefore any meta-action’s breakdown will cause the unusual assembly quality.In order to analyze conveniently, in this paper the letter can be expressed as event and at the same time also expressed as event reliability (reliability is referring to probability of completing rated in rated conditions and rated time, function). According to the reliability theory, the series model reliability can be defined as:

$$R(t) = P(X > t) = P[\min(X_1, X_2, \ldots X_n) > t]$$
$$= P(X_1 > t, X_2 > t, \ldots X_n > t)$$
$$= \prod_{i=1}^{n} P(X_i > t) = \prod_{i=1}^{n} X_i(t) \qquad (1)$$

where, X is the entire serial system; X_i is composition unit of the serial system; $P(X_i > t)$ is the probability of Unit’s normal work in rated time, namely reliability. In order to narrate and express conveniently, the significances of $X_i(t)$ and $P(X_i > t)$ are completely the same. According to the reliability definition of series model and the logical relation of PFMA level, the reliability model of the machine function decomposition process can be shown in Table 1.

4. Cases

First we can adopt the function decomposition principle of “function spectrum - function - movement - action” to carry on the structural analysis of the numerical control rotary table, and the numerical control rotary table has two major functions: one is to clamp the work piece and locate it on the numerical control rotary table; the other is to realize 1°×360 indexing of the work piece. In view of localization and the indexing functions of the numerical control rotary table, the function

decomposition model of numerical control rotary table can be established as in Figure 6.

only realize effective analysis of the product function, but can also solve coupling relations of the

Table 1. Reliability evaluation model of PFM

PFMA	The event logic relationship	Reliability evaluation mathematical model
Function-Level	$R = F_1 \bigcap F_2 \cdots \bigcap F_n$	$R(t) = F_1(t)F_2(t)\cdots F_n(t) = \prod_{i=1}^{n} F_i(t)$ (2)
Movement-Level	$F_i = M_{i1} \bigcap M_{i2} \cdots M_{in}$	$F_i(t) = M_{i1}(t)M_{i2}(t)\cdots M_{in}(t) = \prod_{j=1}^{m} M_{ij}(t)$ (3)
Action-Level	$M_{ij} = A_{ij1} \bigcap A_{ij2} \cdots A_{ijn}$	$M_{ij}(t) = A_{ij1}(t)A_{ij2}(t)\cdots A_{ijn}(t) = \prod_{k=1}^{l} A_{ijk}(t)$ (4)
Pedigree-Level	$R = R_1 \bigcap R_2 \cdots \bigcap R_n$	$R(t) = \prod_{i=1}^{n}\left[\prod_{j=1}^{m}\left(\prod_{k=1}^{l} A_{ijk}\right)\right]$ (5)

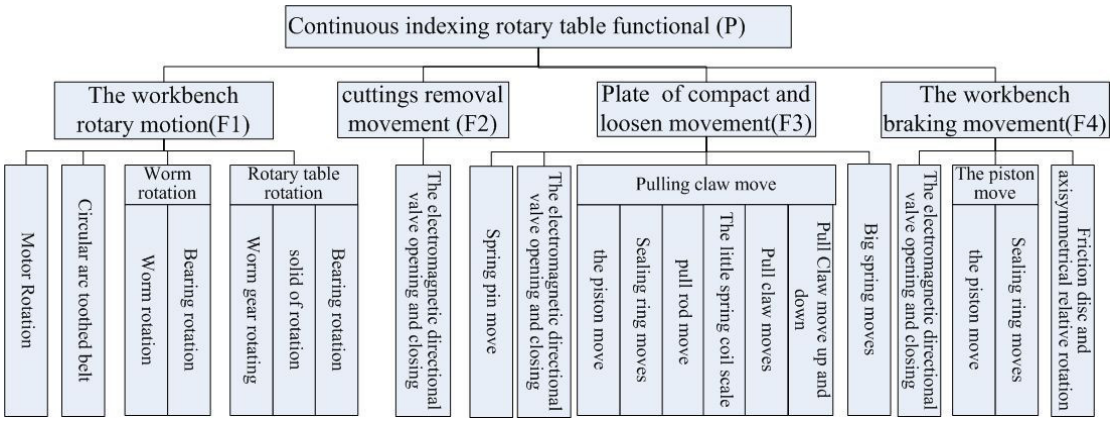


Fig. 6. Functional decomposition model of NC rotary table

The “indexing” and “clamp localization” movement function level of numerical control rotary table function has two movement levels, and the last-level movement is meta-action level. After hoisting work piece to the carrier, we can fix it through the jig in carrier's T groove; the carrier’s bottom surface has 4 die nipples and 4 pull claws; we use pull claws to fix the carrier and the work piece in the rotary table. The indexing system of numerical control rotary table is connected to the AC servo electrical machinery and the worm through the clutch; the worm joggles the wheel to carry on the indexing to the work table through a counter gear vice; and at the same time there are movement coupling relations between numerical control rotary table movements. The function decomposition model can not

decomposition process. In order to guarantee two reliable functions of “indexing” and “clamp localization” in the numerical control rotary table, it needs to guarantee the reliability of meta-action assembly process in the numerical control rotary table. Through the

structural decomposition, by the analysis,meta-action assembly occurs possibly we shall analyze the probable breakdown and the influencing factors, according to the possible factor of meta-action breakdown; we can extract the control point related with reliability. For example, in Figure 6 the possible breakdown of worm rotation and wheel rotation in numerical control rotary table meta-action may be no rotation or not flexible rotation. The reason for two kinds of breakdown may be inappropriate pre-load or tensional pulley failure. In view of above reasons we can treat the bearing pre-tight, pulley tensioning force control and precision guarantee as reliability control points. The reliability control point data in each meta-action assembly process from machine tool factory is shown in Table 2.

In this paper, meta-action assembly unit reliability of the numerical control rotary table is taken as the target quality characteristic, according to the reliability control point data of meta-action assembly unit of numerical control rotary table, we may according to the expert grading method obtain the contribution degree between the reliability characteristic and the linkage in the numerical control rotary table assembly process.

According to PFMA level of the reliable logic event and appraisal mathematical model in Table 1 and reliability control point data in Table 2, the contribution degree between the reliability characteristic and the linkage can be obtained. By using the linkage we can model a "meta-action" and establish linkage network NBL model of numerical control rotary table as shown in Figure 7.

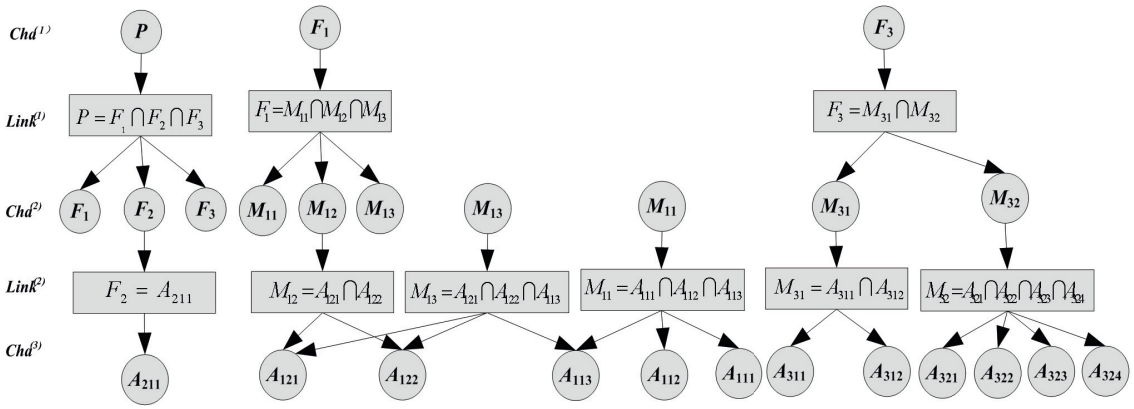


Fig. 7. The reliability model of NC rotary table (NBL)

	Servo motor rotating	Worm rotation	Gear rotating	Reduction pinion rotation	Reduction wheel rotation	Dynamic plate clamp	Dynamic plate of relaxing	Rotary table lifting back	Oil cylinder piston movement	Rack movement	Gear revolve	male coupling tap relax	The mother cone to relax	Pulling claw taut	Rivet clamp	Pulling clamp relax	Tap the clamping	Tap to relax	The mother cone clamping
Rotary table lifting back to zero F_2=A_{211}									0.9										
Dynamic plate of rotary M11=A111∩A112∩A113	0.9	0.8	0.8					0.8											
Dynamic plate positioning M12=A121∩A122						0.7	0.6												
Dynamic plate clamped to relax M13=A113∩A121∩A122						0.9	0.8	0.7											
plate movement M31=A311∩A312										0.9	0.8								
Tap the mother cone to cooperate M32=A321∩A322∩A323∩A324												0.8	0.7	0.8	0.9	0.7	0.6	0.7	0.6

Fig. 8. Matrix based on linkage(MBL) of NC rotary table assembly

In Figure 7, on one hand the numerical control rotary table linkage network model can manifest the evolution of assembly reliability quality in the numerical control rotary table assembly process; on the other hand linkage as the basic connection unit can express incidence relations between the reliabilities.

On the basis of linkages network connection model, we can extract Cha (2) and Cha (3) of reliability quality characteristic as well as Linkage (2), and supplement the linkage and the reliability control point data and contribution degree etc. related information in table 2 from some factory document, construct the assembly process reliability linkage matrix model as shown in Figure 8.

The incidence relation between assembly reliability linkage matrix and the reliability of numerical control rotary table assembly process can be clearly shown in Figure 8. According to reliable series model in Table 1and meta-action assembly reliability control point data in Table 2, we can obtain contribution degree between the reliability characteristic and the linkage through the expert grading in the assembly process of numerical control rotary table, and establish reliability linkage matrix model of numerical control rotary table as shown in Figure 8. The linkage matrix model can be used to calculate related reliability in the numerical control rotary table assembly process.

The contribution degree between characteristic and the linkage in reliability linkage matrix model of numerical control rotary table assembly can calculate all levels of reliability, and substitute them into the formula (6) to calculate the reliability R (t) of numerical control rotary table assembly:

$$\begin{aligned} R(t) &= R_1(t)\bullet R_2(t)\bullet R_3(t) = F_1(t)\bullet F_2(t)\bullet F_3(t)\bullet \mathrm{F}_4(t) \\ &= [\mathrm{M}_{11}(t)\bullet M_{12}(t)\bullet M_{13}(t)]\bullet \mathrm{A}_{211}(t)\bullet[\mathrm{M}_{31}(t)\bullet M_{32}(t)] \\ &= A_{111}(t)A_{112}(t)\bullet\cdots A_{324}(t) \\ &= 0.778 \end{aligned}$$

According to the computed result of assembly reliability and aiming at the size of reliability, we can make effective measures for various control points to enhance the reliability of assembly process.

On the basis of method research, in order to enhance the reliability of assembly process, we can trace the control point of low reliability and provide the rationale and technical support for the reliability-driven assembly technique plan.

Table. 2 Meta action assembly unit reliability control data

Reliability of the control points	time				
	2008	2009	2010	2011	2012
The bearing pre-tightening force accuracy	0.987	0.988	0.978	0.993	0.996
Wheeled the qualification rate of tension control	0.811	0.799	0.775	0.823	0.821
Precision of parts qualified rate	0.987	0.983	0.975	0.980	0.990
Worm gear, bearing, spindle alignment control the percent of pass	0.984	0.980	0.985	0.986	0.989
Bearing screw fastening torque accuracy	0.991	0.993	0.985	0.986	0.992
Worm and gear mesh clearance rate control	0.996	0.997	0.995	0.994	0.998
Reading head clearance rate control	0.876	0.854	0.867	0.886	0.895
Grating ruler connection reliability	0.789	0.778	0.781	0.785	0.786
The hydraulic oil average qualified rate of the data in the system	0.997	0.996	0.997	0.995	0.998
Hydraulic oil inlet flow rate average data in the system	0.997	0.994	0.996	0.998	0.998
In the hydraulic system leak control average qualified rate	0.999	0.998	0.997	0.999	0.998
Inductive switch and control clearance between induction percent of pass	0.978	0.986	0.974	0.977	0.998
Gas path flow rate	0.997	0.998	0.996	0.997	0.979
Male coupling tap same high-precision control percent of pass	0.975	0.986	0.978	0.975	0.984
Male coupling tap position accuracy control percent of pass	0.975	0.967	0.958	0.956	0.978
The qualification rate of relaxation time control	0.879	0.857	0.893	0.889	0.891

5. Conclusions

(1) The method of PFMA structural decomposition is proposed in this paper, the essential functional unit of numerical control rotary table in numerical control

machine is taken as the example, and the decomposition of “spectrum system - function - movement - action” has been carried out.

(2) Research on the quality characteristic modeling technology of assembly process reliability has been conducted on the basis of the structural decomposition. By the method of expert grading and from some machine factory's reliability control point historical data, we can obtain the contribution degree between reliability characteristic and the linkage. Thus, the structural linkage network and the linkage matrix model have been bulit and the computation to the numerical control rotary table assembly reliability has been conducted, which lays the model foundation of the reliability quality characteristic analysis in the assembly process.

(3) On the basis of this method research, in order to enhance essential quality characteristic such as assembly process reliability etc., the control point of low reliability can be traced. Thus, the rationale basis and technical support for the reliability-driven assembly technique plan can be provided.

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